

Information and Communication Technologies in Education: Video Games as an Effective Environment for the Development of Self-Directed Learning of Students

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Abstract

The research analyze the ways of integrating serious video games into the educational environment. The article defined at the theoretical level the features of using video games as an effective environment for the development of self-directed forms of students' learning. Based on an expert survey, the authors determined the motivations for students' participation in a video game, key features of gaming communities, levels of decision-making, and problematic issues for creating a favorable gaming environment, as well as scenarios for integrating video games into the educational environment. The research results have confirmed the assumption that serious video games are an effective means of developing independent forms of students' learning.

Keywords

Serious Video Game, Learning Environment, Game-based Learning Environment, Video Game Integration.

Introduction

Until recently, digital video games were associated by many with negative impact on the physical and mental health of players (Lager, Bremberg, 2005). However, contemporary research has shown that if one adheres to appropriate gaming habits (for example, proper time and game-based environment, moderation of online games, etc.), they can be considered safe and full-fledged activities (Griffiths, 2005; Pereverzeva et al., 2020; Korotaeva, 2020).

It should be noted that since 1980, information and communication technologies have been implemented into pre-school, primary, secondary, and higher educational institutions. Video games appeared in classrooms in the early 1990s. With the implementation of each new technical tool into the educational process, curriculum developers solve the issue of how it can optimize the learning process (Avksentieva et al., 2019; Martynova et al., 2020). Computer video games have become the focus of such research just recently (Mayer, 2016).

At that, researchers call serious video games those that are designed on the game-based principles but used especially for learning or training rather than for entertainment (Schollmeyer, 2006; Pereverzeva et al., 2020). Serious games combine the typical elements of video games, such as multimodality, interactivity, the specific organization of the game situation, narrative, and social goals. Besides, they provide constant feedback in the form of points, or changes in the game scenario, by which players track their movement towards the set goal (Sanford et al., 2015; Golubeva et al., 2020).

Literature Review

The theoretical review conducted by the authors suggests that the scope of research related to serious video games at the international level is very broad. For example, M. Dondlinger (2007) and B. Gros (2007) investigate game design; R.P. De Lope and N. Medina-Medina (2016) study the taxonomy of serious video games; C. González and F. Blanco (2012) focus on ways to develop training games; A. F. Anderson, D. Bavelier (2011), W. R. Boot, and A. F. Kramer (2008) analyze the motivational and cognitive impact of video games. Numerous studies have covered various aspects of the use of video games in teaching foreign languages (Liu, Chu, 2008), literature (Hui-Yin, Shiang-Kwei, 2010), physics (Anderson, Barnett, 2011), and various scientific concepts in general (Hsu et al., 2016).

Researchers are systematically disseminating the idea of the need to use computer games for teaching and learning through serious games. In particular, L.A. Annetta with coauthors sees the potential of video games in the assimilation of the conceptual, behavioral, and

operational content of learning by game participants. According to scientists, it is video games that can reproduce a certain historical period, produce situations that help to learn STEM subjects and create the field for searching for new opportunities and alternatives (Annetta et al., 2006). It is this possibility based on a simulation that makes it possible to study phenomena, address problems, and transfer the gained experience to other activity areas, which is of great pedagogical value (Annetta et al., 2006).

Thus, contemporary scientists see the following advantages of teaching using serious video games. First, serious video games create a unique learning environment that absorbs its participants and, at the same time, pursues specific pedagogical goals with predictable results (Toh, Kirschner: 2020). Second, video games are associated with cognitive changes, have motivational influence, and sociocultural consequences (Mayer, 2019).

Today, serious video games are successfully used in such sectors as government agencies, defense organizations, healthcare institutions, marketing and communications, education, corporations, and industry (Khouna et al., 2020; Bukhteeva et al., 2019). Scientists agree that formal and informal education is one of the most promising areas of active use of serious video games (Hanid et al., 2020). However, the issue of using a video game as an effective environment to develop self-directed forms of student learning when studying the computer science still remains relevant.

Considering the above, the purpose of the present article is to analyze the ways of integrating serious video games into the learning environment to develop self-directed learning forms of students when studying the computer science.

Research hypothesis is as follows: a serious video game is an effective means of developing self-directed learning forms for students when studying the computer science and when taking into account the motivations of students' participation in the video game, key features of gaming communities, levels of decision-making and problematic issues for creating a favorable game-based learning environment, and implementing adequate scenarios for integrating video games into the learning environment.

Further, the article presents the description of the research methods used, the results of the research based on an expert survey, the discussion of the results and the conclusion with the final outcomes of the research.

Methods

To achieve the goal set in the study, the authors have defined an approximate suite of theoretical and empirical research methods:

- Theoretical methods (analysis, synthesis, comparison, and generalization) were used for studying the scientific literature on the research problem
- Empirical methods (expert survey).

The expert survey was the main method of the present research. The survey involved experts (40 people, including 25 men and 15 women), who were employees of Russian higher educational institutions with more than five years of teaching experience, and related due to their professional activities to the integration of educational video games in the students' teaching process.

Experts were asked to fill out voluntarily a semi-formalized questionnaire related to the problem of integrating video games into the educational process, including the following questions:

- What are the motivations for students' participation in video games and key features of gaming communities?
- What are the levels of decision-making, as well as problematic issues for creating a favorable gaming environment?
- What are the scenarios for integrating video games into the educational environment when studying the computer science?

The experts participating in the survey were warned about the purpose of the survey and the future publication of the research results in a generalized form with all the quotes of experts in an anonymous form.

Results

An expert survey has shown the following motivations to participate in a video game (Table 1).

Table 1 Motivations for students to participate in a video game

No	Motivations	%*
1	Control over the game characters and the game environment	90%
2	Challenge – the desire to achieve a higher level of skill	87.5%
3	Competition – the desire to win or surpass others	85%
4	Fantasy – engaging in actions that are unrealistic in everyday life	82.5%
5	Interest – a desire to learn the game and collect information	80%
6	Distraction from everyday problems by immersing into the game	80%
7	Social interaction – the desire to play with each other and against each other	75%

Note: compiled based on an expert survey; * – percentage of expert mentions

No less relevant in the context of the present article is the consideration of conditions for creating a favorable environment for the integration of serious video games into the educational process of a particular educational institution. Based on the expert survey, it was revealed that the main stakeholders in the process of creating a game-based learning environment in a particular educational institution were the administration, IT departments, teachers, and students. At that, the administration, IT departments, and the teachers were responsible to solve problematic issues related to creating a favorable game-based environment (Table 2).

Table 2 Levels of decision-making and examples of possible problematic issues when creating a favorable game-based environment

Decision-making level	Examples of challenging issues
At the administration level	<ul style="list-style-type: none"> • What do contemporary studies show concerning the educational potential of serious video games? • What educational materials are available for parents and society? • How to better demonstrate the link between video games and the development of 21st-century skills (developing creativity, critical thinking, collaboration, leadership, and responsibility) to gain public support? • How best to create a team of leaders of the educational space to implement educational innovations, in particular, serious video games? • How to organize support for teachers who are trying to use new educational technologies (for example, to reduce the administrative burden)?
At the level of IT departments	<ul style="list-style-type: none"> • What technical resources are needed at the stage of implementation and further support of educational video games? • How to simplify the process of installing and updating programs? • What are the rules/restrictions on access to portals, the Internet, etc.?
At the level of academic staff	<ul style="list-style-type: none"> • What is the role of the teacher as an information resource? • Who can provide support (reference group)? • What is the proof of the training games effectiveness? • Do the selected games meet the educational standards? • What is the advantage of video games as a learning tool? • What are the options for integrating video games into the learning environment? • How are roles and responsibilities distributed between teachers and students? • What is the structure of the game? • How to use the experience of participation in the game to form the skills of the 21st century (developing creativity, critical thinking, collaboration, leadership, and responsibility)?

Note: compiled based on an expert survey

According to one of the experts interviewed, "convincing all parties to support learning using serious video games requires more effort than developing traditional teaching and learning aids. For example, teachers need to be convinced that extra effort will lead to improved results. The administration should be familiar with research results and references that explain the pedagogical advantages of educational video games. Even students need support to understand how games can be used for learning rather than entertainment".

Thus, the expert survey revealed the need to use comprehensive impact on the administration, technical structure, and teachers who could become leaders in political, technological, and pedagogical aspects.

Experts believe that another important factor in integrating serious video games into the educational environment is the awareness of interested parties (teachers and administration) concerning the existence of several possible scenarios for using video games to develop self-directed forms of education for students.

The experts suggested considering the following six scenarios for video game integration when studying the computer science: 1) using one game during a session (lesson); 2) using one game for several sessions; 3) using a specific game element as an additional task; 4) integrating a full game into the curriculum; 5) using an online game as part of a mixed learning or online course; 6) implementing a game into the mixed reality (Table 3).

Table 3 Scenarios for integrating video games into the learning environment when studying the computer science

No	Scenario	Basic possibilities
1	One game during a session (lesson)	This scenario is considered the simplest and least radical way to implement computer game-based training. Typically, this scenario involves the use of games during one lesson (during one academic session) to achieve specific objectives. For example, to activate the work of a student group or use an alternative approach that would take into account different learning options.
2	One game for several sessions	This scenario is used as a direct substitution of two or more training sessions. The disadvantage of the scenario is associated with the possible lack of time needed to explain the learning situation to students, providing primary instructions on how to play the game. In this scenario, it is recommended to use other additional tasks, to conduct reflections on the gained game experience between sessions.
3	A game element as an additional task	In this case, the video game does not substitute the learning session. The advantage is the ability to attract less motivated and less active students to study.
4	Integrating a full game into the curriculum	The digital game is used as an alternative means of presenting material, which, in turn, leads to a realignment of the teaching, learning, and evaluation process, up to a realignment of the curriculum. In this case, the

		game becomes the focus of learning. Among the disadvantages of this scenario can be the fact that students may underestimate the game-based approach, which leads to a low level of student involvement, or refusal to participate in the work. This scenario is the riskiest since the entire course is based on the use of a video game, that is, it imposes certain requirements regarding the proportion between the game and the standards of university programs and a specific course.
5	An online game as part of a mixed learning or online course	In this case, students do not necessarily have to meet each other at all, because the game is played online, either synchronously or asynchronously. This scenario can be based on the use of virtual worlds and unite players who work independently, supporting each other if necessary to share resources or tips. It is important to develop communication methods to support players in a mode where training takes place without the direct participation of the teacher
	Implementing a game in the mixed reality option	In this scenario, elements of the network environment are used, as well as personal interaction, often involving mobile technologies, such as mobile phones or other portable devices. Using problem-bearing, experimental, and general tasks in an alternative game format makes mixed reality an ideal approach for teaching in the higher education institution

Note: compiled based on an expert survey

Discussion

Analysis of the expert survey results allows concluding that there are two main areas of serious video games influencing the educational process. The first is the ability of serious video games to change cognitive processes, and the second is their impact on the motivational sphere.

The idea of changes in the cognitive process is supported by the theory of Learning by Action, as well as constructivism, which indicates that the most effective learning is reached based on personal experience gained through the implementation of certain activities (performing certain actions) provided obtaining immediate results. In the context of this theory, learning occurs through solving problems using the method chosen by the learner to solve it. The experience gained in this case is enriched by reflection, becoming deeper (Bediou et al., 2018).

Indeed, as experts point out, serious video games as tests provide students with integrated topical issues or projects that they can accept or reject. The learning environment offers participants the tools and resources they need to understand the problem and solve it, as well as allows players to explore, experiment, design, communicate, and reflect on what they are doing – that is, learn based on personal experience.

In the context of a cognitive approach, training should also be aimed at increasing the amount of knowledge in long-term memory, developing strategies for storing and using information, cognitive activity, selecting appropriate information, organizing it into a sequential structure, and integrating into previously accumulated knowledge.

To date, there is already a sufficient number of experimental works which indicate that the use of serious video games is more effective in comparison with traditional forms of learning. At that, the material learned through video games is stored in the students' memory for longer, is more structured, and serves as a solid basis for further knowledge accumulation. Memorization in the course of a video game occurs through repetitive tasks and auxiliary rewards that encourage storing educational material in memory. Analysis and understanding of the material are achieved by direct interaction with the game objects, free experimentation, and investigation of the relationships between various phenomena when performing problematic tasks. Assessment skills are developed by simulating game objects and processes and changing them to achieve better results. Video games also allow players to create new artifacts and processes, as well as test them experimentally (Cameron, Dwyer, 2005).

Other equally important cognitive qualities that are formed during a video game, mentioned by the experts, are logical thinking, motion coordination, spatial perception, as well as learning to cooperate that prepares students for further learning and solving other problematic situations.

While talking about the ability of serious video games to influence the motivational sphere, experts note that the student's interest in the certain discipline arises when he understands what the teacher is talking about, when the tasks are interesting, when it is needed to think for himself, make conclusions, generalizations, when the student sees the prospect of using the acquired knowledge in practice. Therefore, using game technologies in the educational process is effective for increasing the motivation of students to learn.

Papastergiou M. (2009) describes the following four motivational factors which can be attributed also to serious video games. These are interest, control, imagination, and a problematic task. Thus, entering the game environment, the student faces a kind of astonishment, clear and achievable goals, several choices that lead to significant consequences, as well as the relationship between the narrative of the game and the skills that the player acquires in the simulation process. D.M. Adams and D.B. Clark (2014) add a competition as another important element of computer game-based learning, whose presence, according to the researchers, increases their motivational potential.

Other arguments in support of serious video games related to the results of an expert survey indicate that serious game-based training is more effective than traditional learning. The material learned through video games is stored in the memory of students for longer and is more structured, which serves a solid basis for accumulating further knowledge. Besides, according to experts, students taking part in the game can share their knowledge with other players, who often have different social and cultural adscription. This allows creating communities that explore relationships in an information-rich environment, rather than just study the viewpoint of the author of the textbook, who follows the planned path and presents the information based on his perception (Dolzhenkov et al., 2020; Skripak et al., 2020).

Thus, serious video games create a unique educational process that absorbs participants and at the same time pursues specific pedagogical goals, and assumes certain results.

While pointing out the problem areas associated with the use of serious video games in training, experts mention the following:

1. The game is still perceived by many educators as an occupation for spare time without much educational value.
2. There is an urgent need to develop clear expected outcomes of learning using serious games, which would be consistent with curriculum standards.
3. Today, there is a need to develop teacher training courses for working with serious games, which would explain the expected results of such training, introduce teachers to various game interfaces, and provide information about the principles and processes of video game-based learning.
4. Developing ways to transfer the skills acquired by students during the game to different contexts of everyday life is also quite a relevant issue. In this aspect, the question arises again concerning the role of the teacher and his perception and regulation of such an educational process, his ability to provide students with reflection and contextualization of the acquired skills and knowledge in new scenarios.
5. Certain problems are associated with lack of equipment, lack of required number of modern graphics cards, compliance of games developed with technological abilities of the particular educational institution.

In general, the results of the research have confirmed the assumption that a serious video game is an effective means of developing self-directed learning forms for students, provided consideration of the motivations of students' participation in the video game, key features of gaming communities, levels of decision-making and problematic issues for creating a

favorable game-based learning environment, and implementing adequate scenarios for integrating video games into the learning environment.

The data obtained during the expert survey are consistent with the results of studies determining the ability of serious video games to change cognitive processes (Bediou et al., 2018; Cameron, Dwyer, 2005; Dolzhenkov et al., 2020; Skripak et al., 2020) and to influence the motivational sphere of students (Papastergiou, 2009; Adams, Clark, 2014).

The authors see the practical value of the presented work in promoting the idea of using serious video games as an educational tool in higher education to develop self-directed forms of education for students, as well as attempts to analyze ways to involve teachers in this process.

Further research prospects of the topic under consideration are associated with the development of a program for training game participants to use serious video games in practice that will make teachers full actors in the process of using and developing serious video games, and contribute to the effectiveness of teaching techniques of the 21st century.

Conclusion

Serious video games as technological and cultural artifacts have significant impact on contemporary society. At the same time, serious computer video games are aimed at using an entertainment component for training and learning. Formal and informal education is one of the most promising areas of the active use of serious games. Based on the principles of action learning, serious computer video games possess the potential to overcome many of the limitations of traditional learning. They contain more complex and diverse approaches to the learning process, allowing using interactivity, promoting collaboration, and supporting active learning.

Contemporary studies of serious video games recognize them as a full-fledged safe educational tool that can create a unique learning environment that affects the cognitive, motivational, and social spheres of game participants. As a new tool, serious video games require a comprehensive approach when integrating them into the educational process. At that, the authors consider it appropriate to take into account the levels of decision-making (administration, IT departments, teachers, and community), as well as problematic issues that accompany the transition of an educational institution towards using digital gaming technologies. Equally important is the knowledge of alternative scenarios for using video games in the educational process.

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